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Mission Data:

What We Have & What We Want

- **Current state:** *Precisely locating scientific data down to **mm accuracy** on the surface of a planet, especially in-situ data, takes **days to months** (instrument dependent) and multiple persons. Valuable spatial relationships can remain hidden, resulting in loss of mission performance.*
- **Objective:** *Develop standards, tools, and interfaces for providing and accessing **localized instrument data**.*
- **Desired state:** *Near-real time (i.e. **daily**), automated access to science data results in a **mapping interface**.*

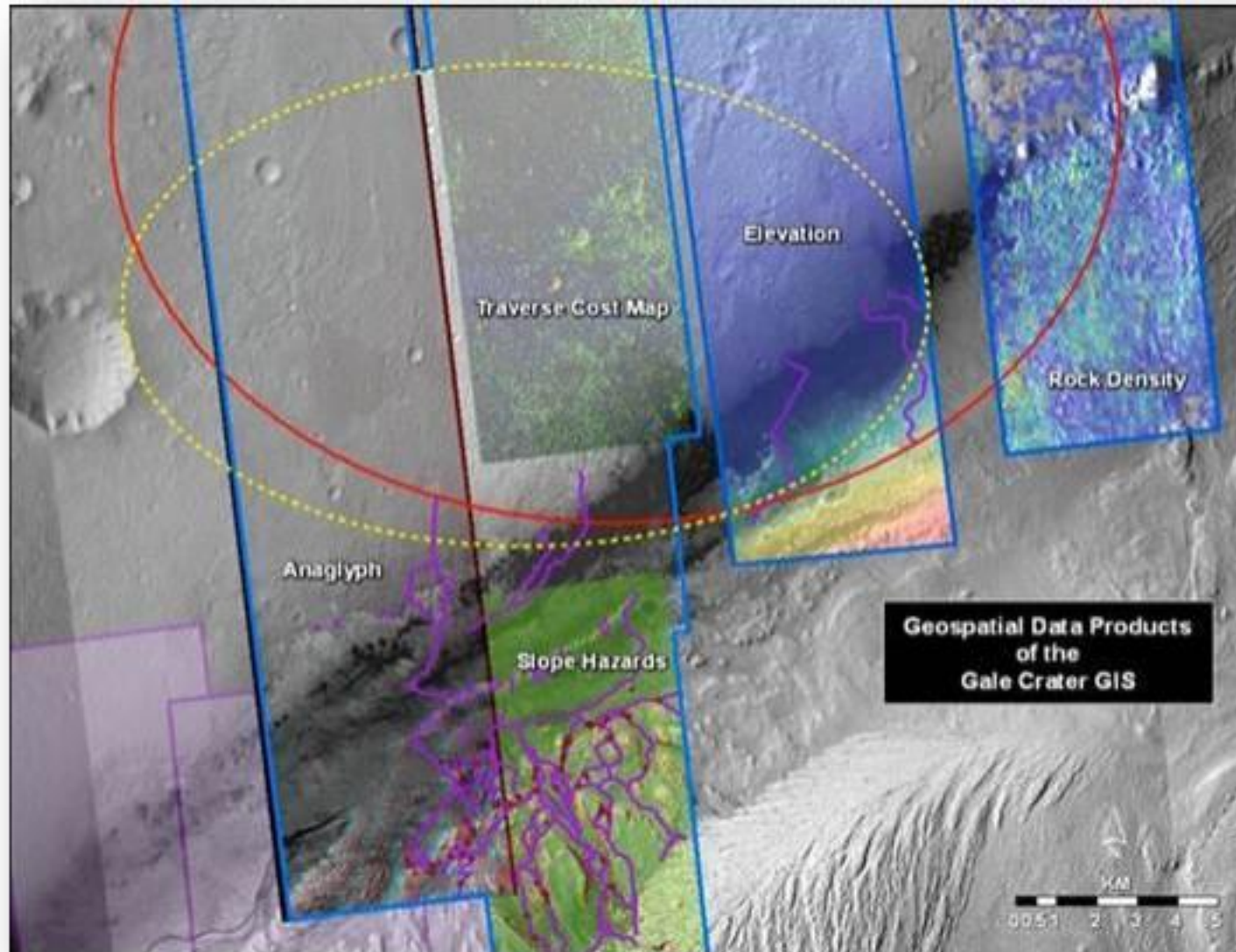
MMGIS Goals:

- **Define labels and methodology** for localizing any science instrument data to a planetary surface *during science data creation*.
 - Planned/telemetry
 - As-run/localized
- **Automate localization for any instrument** type or platform (i.e. orbital mount, instrument mast, or robotic arm).
- **Develop mapping interface** for science and engineering teams to quickly assess and utilize recent results. *More than points on a map.*

Strategic Goals

- ***Reduce Mission Operations cost and risk*** – reduce processing time and improve scientific cross-comparisons between instruments
- ***Leverage appropriate technological advances and emerging standards*** – provide web-enabled map content for all instruments using free and open-source software (**FOSS**) across multiple computer platforms (**PC, mobile**)
- ***Broaden Support for Future Missions*** – standardize recording **3D position** of landed and rover instrument science data

Multiple Co-Registered Datasets: Slope, Rock Abundance, Hazards



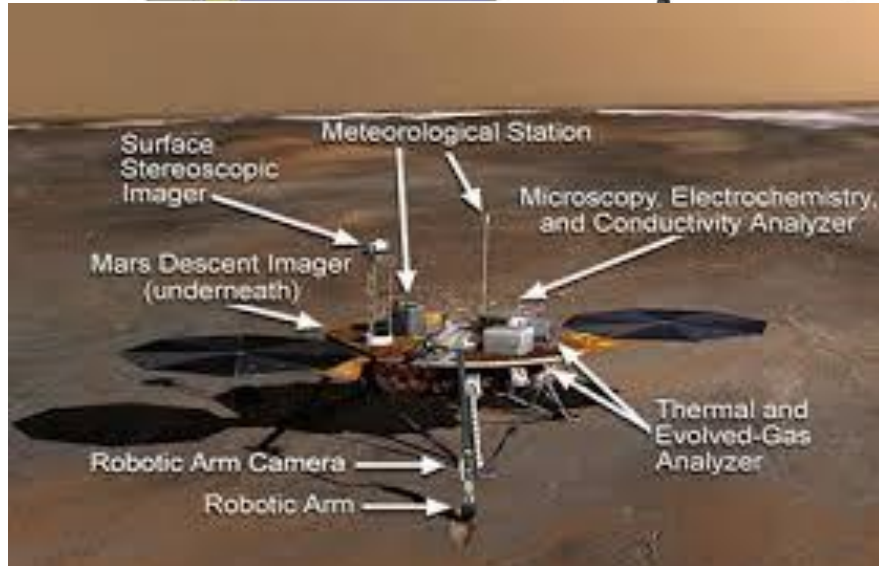
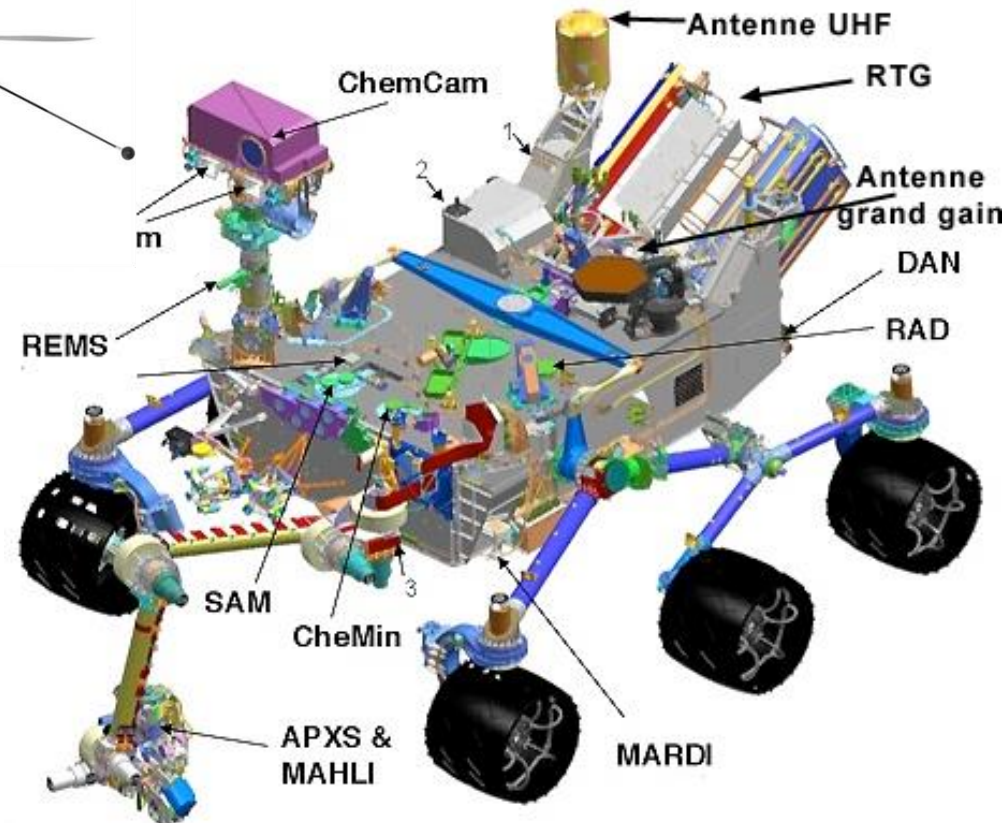
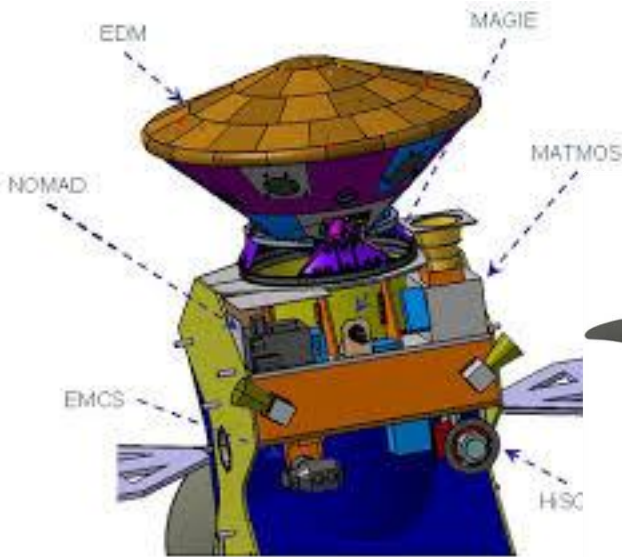
So Many Instruments, So Little Time

Spacecraft types

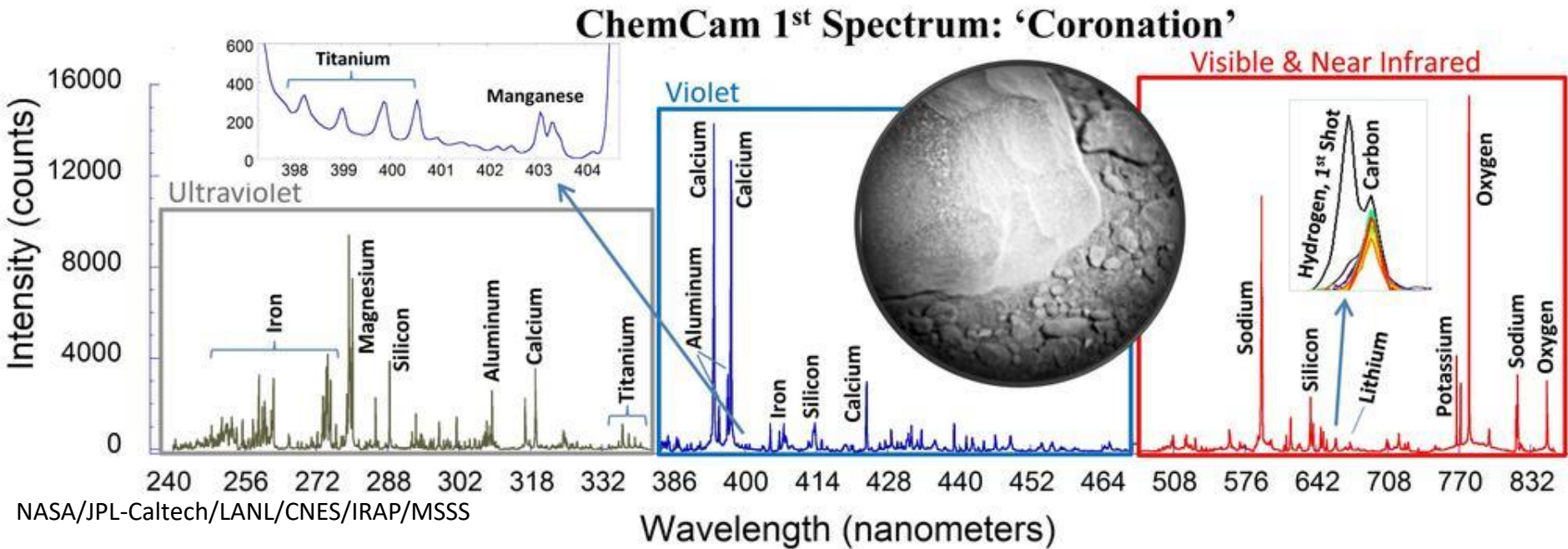
- Orbital
- Sub-Orbital
- In-Situ Remote
- In-Situ Contact

Instrument Types

- **Body-fixed**
(MARDI, REMS, DAN)
- **Pointed**
(MASTCAM, CHEMCAM)
- **Contact**
(APXS, MAHLI, DRILL)



Great data, but where is it!?!



NASA/JPL-Caltech/LANL/CNES/IRAP

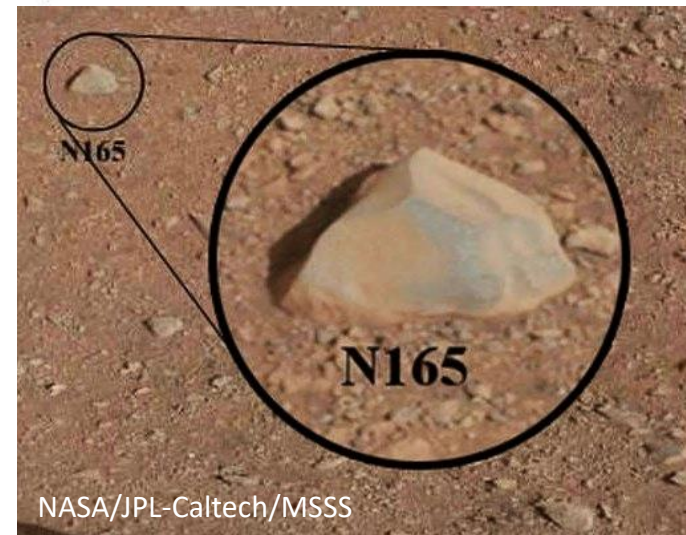
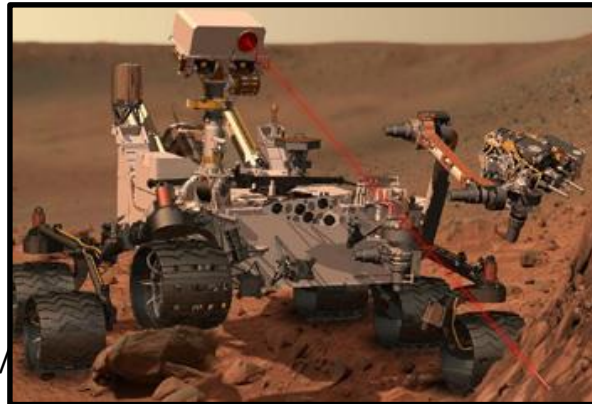
Target: Coronation (N165)

Sol 13

Shots: 30

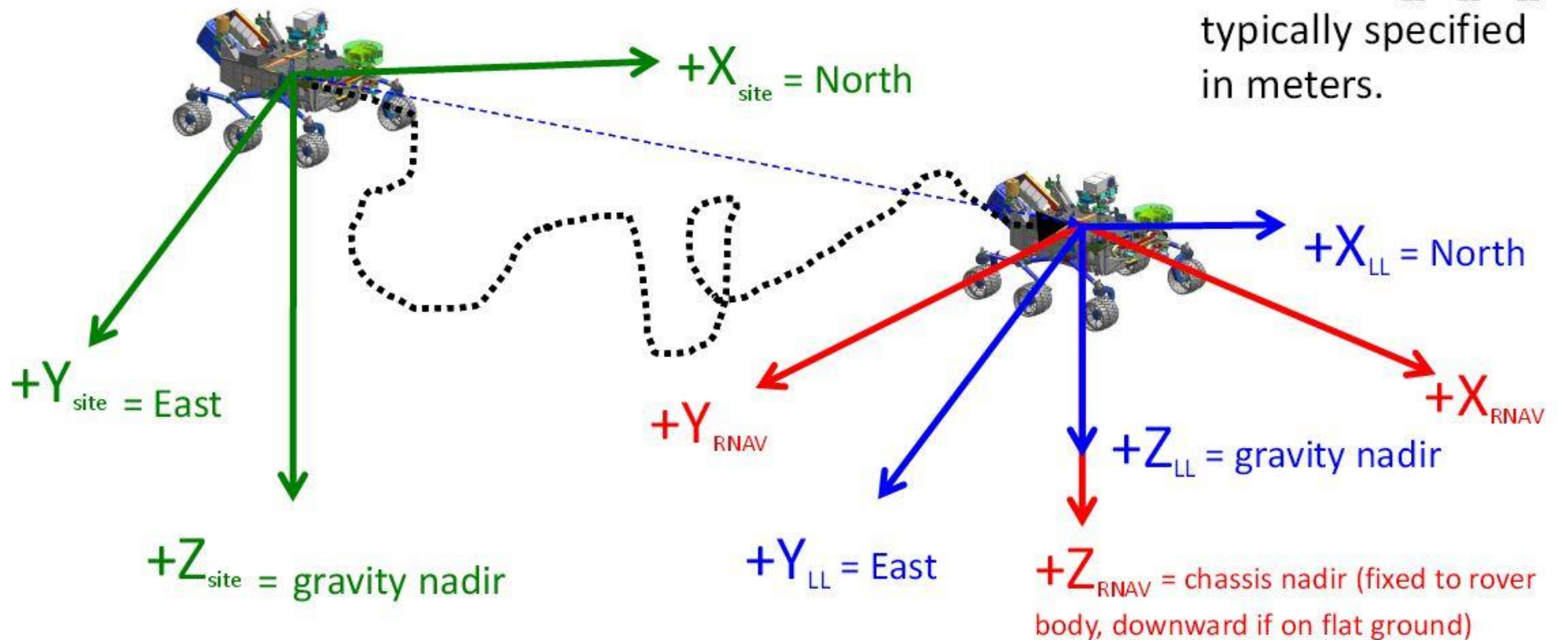


NASA/



Rover Coordinate Frames

1. Declare a site frame



Instrument Coordinate Frames

Frame Type	FRAME	Description
Mobility	WHEEL_LF	Left front wheel
	WHEEL_RF	Right front wheel
	WHEEL_LM	Left middle wheel
	WHEEL_RM	Right middle wheel
	WHEEL_LR	Left rear wheel
	WHEEL_RR	Right rear wheel
	NAV_GOAL	Current rover navigation goal
	NAV_VTT	Visual Target Tracking target
	WHEEL_RR	Right rear wheel
Remote Sensing Mast (RSM)	RSM_BASE	RSM base
	RSM_HEAD	RSM head
	RSM_JOINTS	Joint-space (coordinate type must be JOINTS_ABS)
	NCAML	Left Navcam on active rover computer
	NCAMR	Right Navcam on active rover computer
	RMI	ChemCam Remote Micro Imager
	MCAML	Left Mastcam
	MCAMR	Right Mastcam
	CCAM_CAL	ChemCam calibration target
Inertial Vectors	MCAM_CAL	Mastcam calibration target
	SUN	Sun
	Earth	Earth
	Phobos	Phobos
	Deimos	Deimos

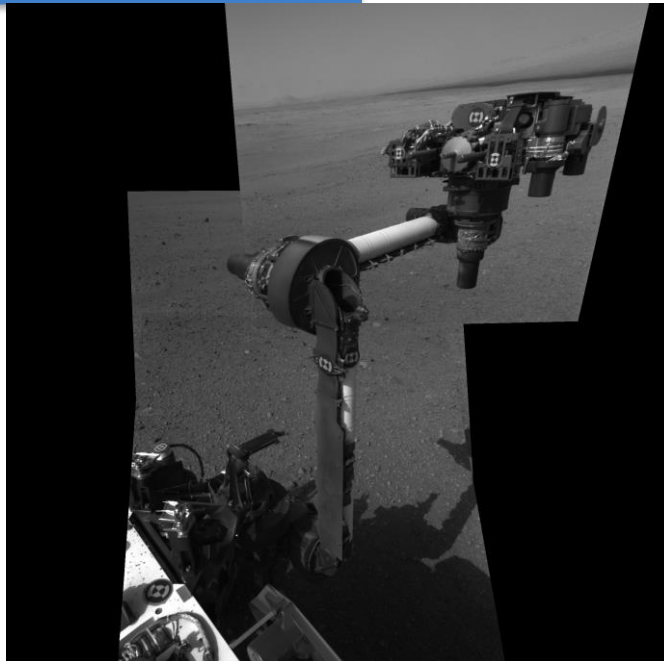
Frame Type	FRAME	Description
SA/SPaH	ARM	Robotic arm base
	TURRET	Robotic arm turret
	MAHLI	MAHLI
	SCOOP_TIP	Scoop tip
	SCOOP_TCP	Scoop tool control point
	PORTION	CHIMRA portioner
	APXS	APXS
	DRILL	Drill
	DRT	Dust removal tool
	ARM_TGT	Arm target
	ARM_GUARDED	Last arm guarded move
	DROPOFF	CHIMRA dropoff frame
	SAM1	SAM inlet 1
	SAM2	SAM inlet 2
	CHEMIN	Chemin inlet
	OCM1, OCM2, etc.	Indexed Organic Check Material
	TRAY	observation tray
Other Body Mounted	RAD	RAD instrument on the rover deck
	REMS_UV	REMS UV sensor on the rover deck
	REMS_BOOM1	REMS Boom 1
	REMS_BOOM2	REMS Boom 2
	HCAML	Left Hazcam on active rover computer
	HCAMR	Right Hazcam on active rover computer
	FIDUCIAL	Indexed fiducials

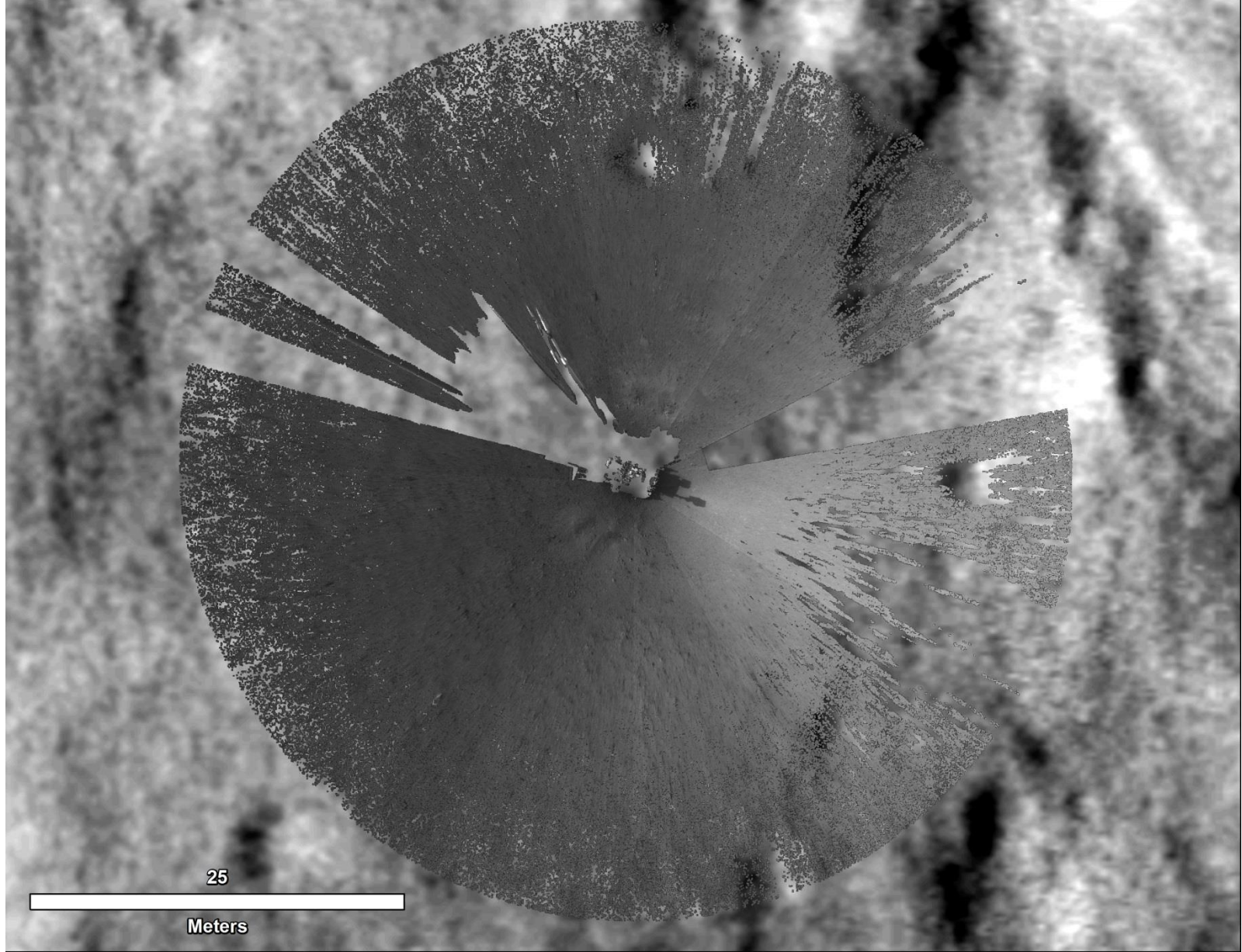
Localization Steps

Rover to Basemap
(site frame to Mars
northing, easting,
elev to sub-meter)

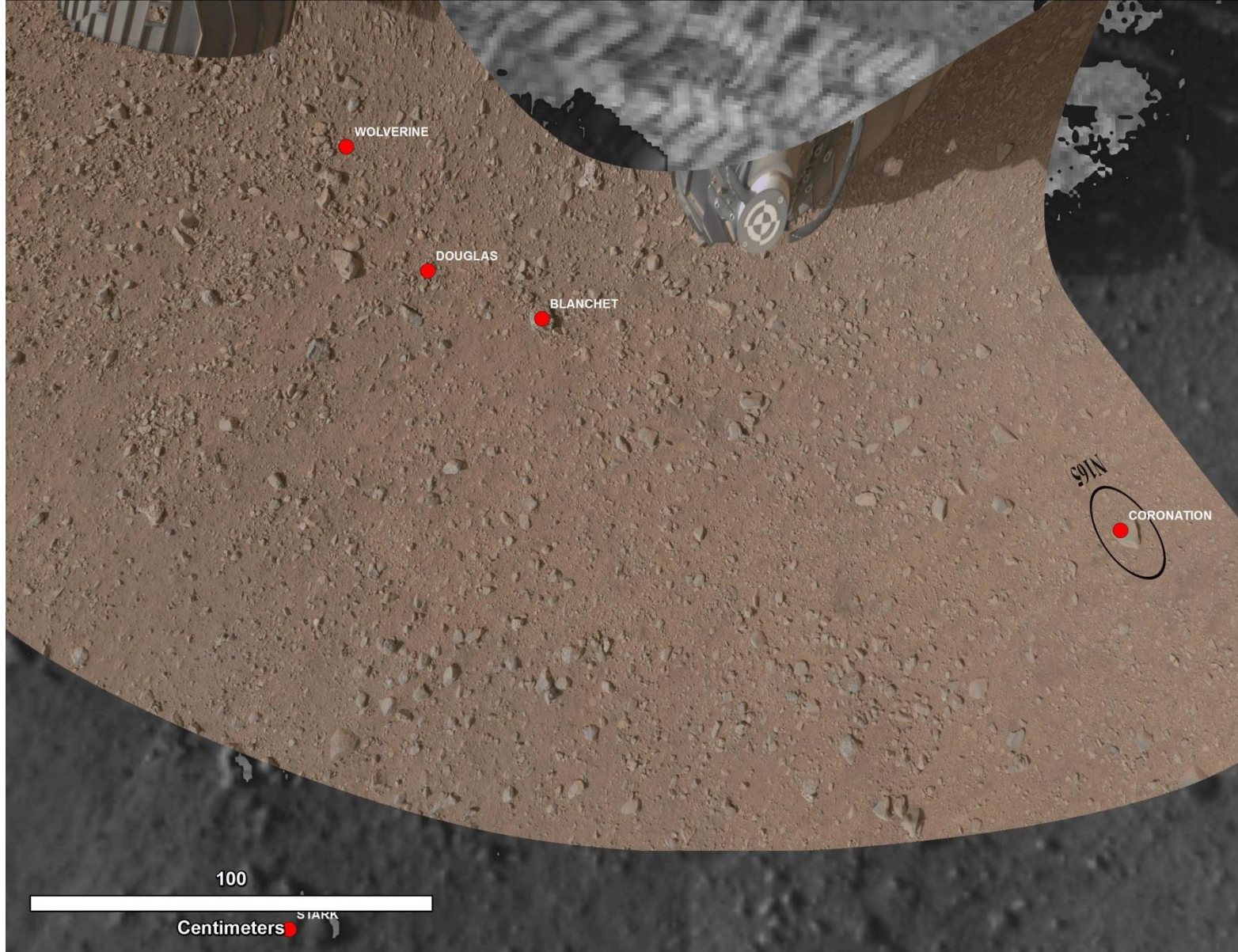


**Science targets
relative to Rover**
(correct for rover
orientation,
pointing, arm joint
angles to sub-
centimeter)

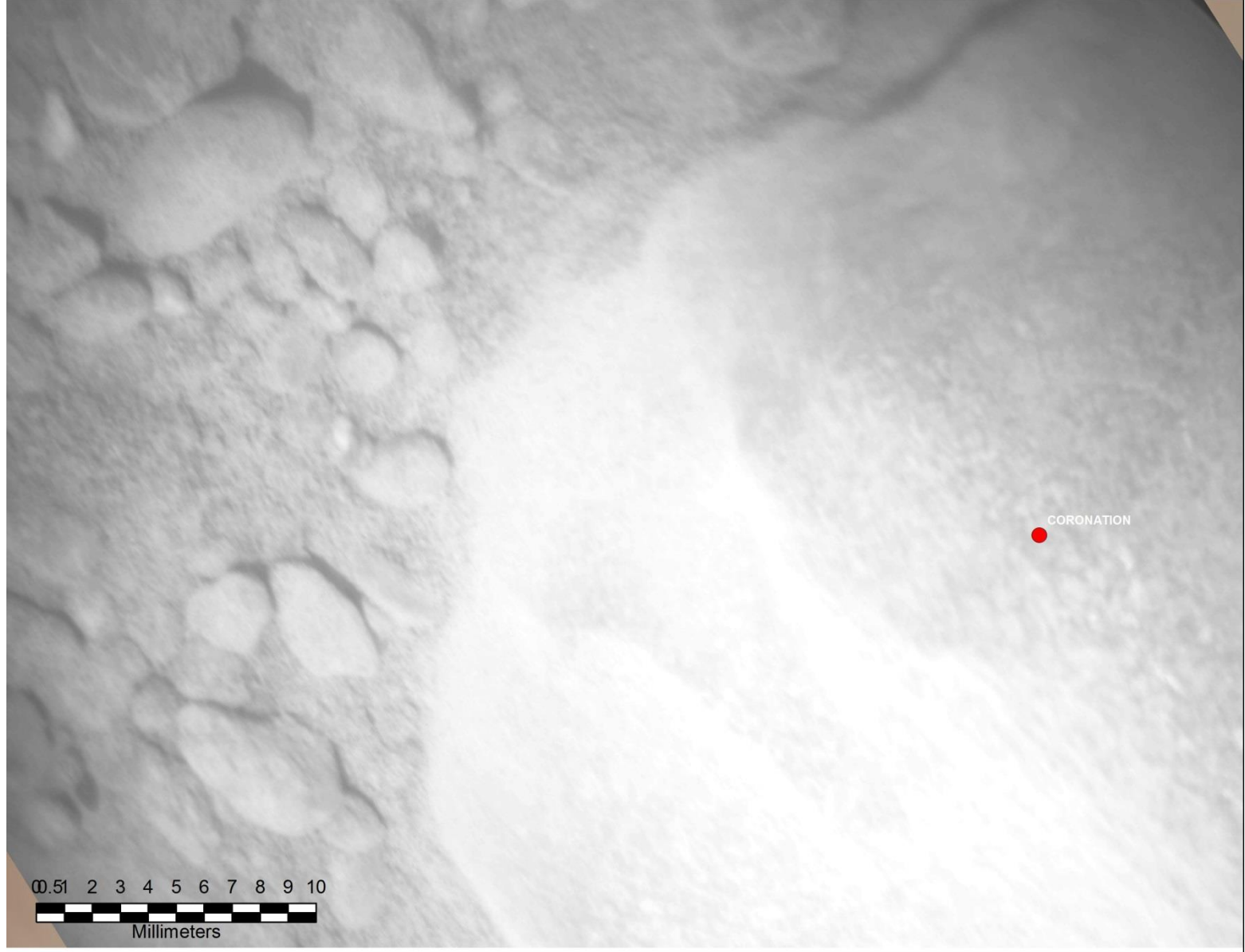




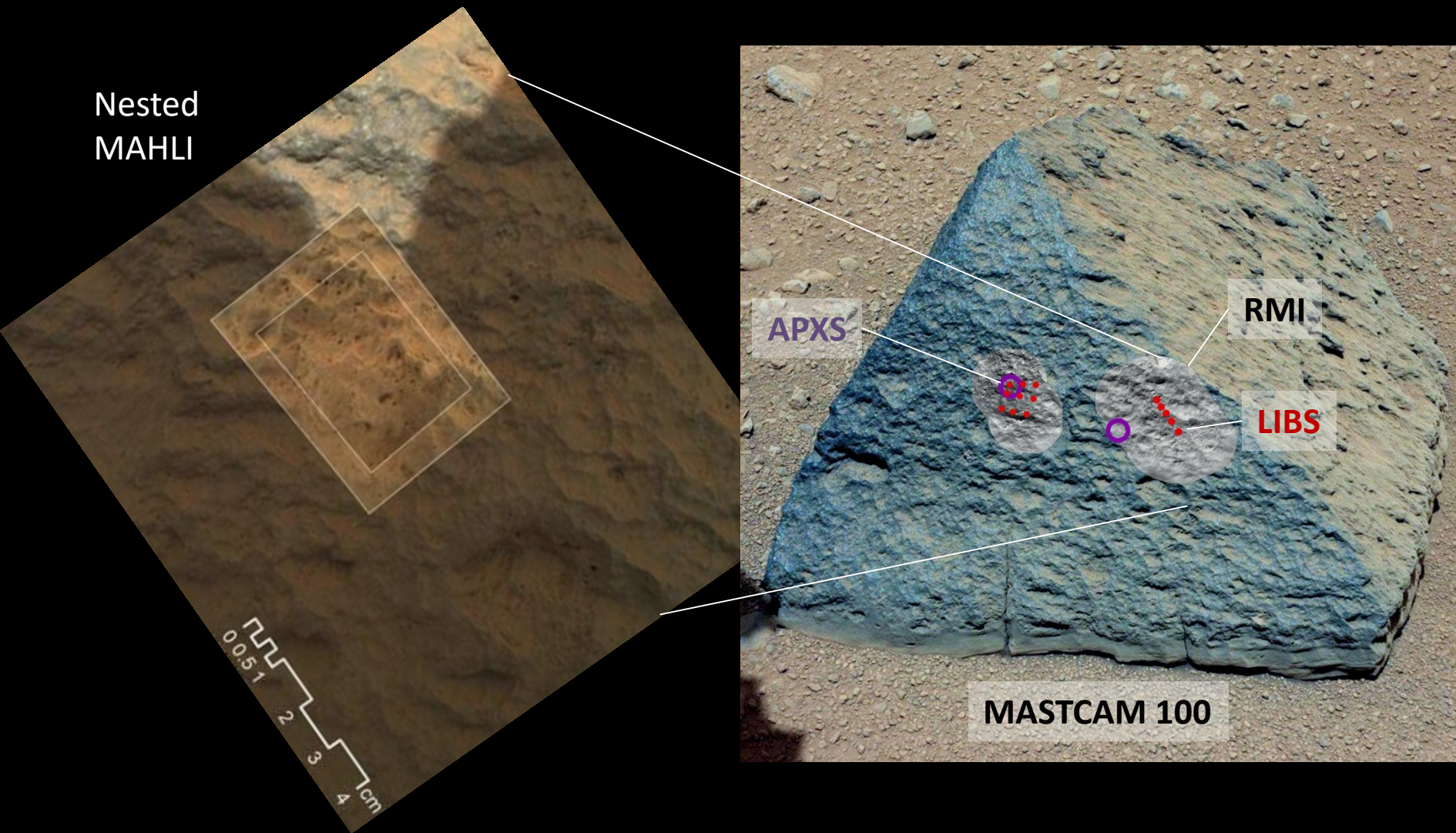
Descent to Ground: HiRISE (0.25 m/p) to MARDI (12.5 m/p) to NAVCAM Orthophoto (1 cm/p) (gravels)



**Ground to rock: NAVCAM to MASTCAM 100
(1 mm/p) (coarse sand to fine gravel)**



Rock to sand: MASTCAM 100 to RMI (~100 microns/p) (fine to very fine sand)

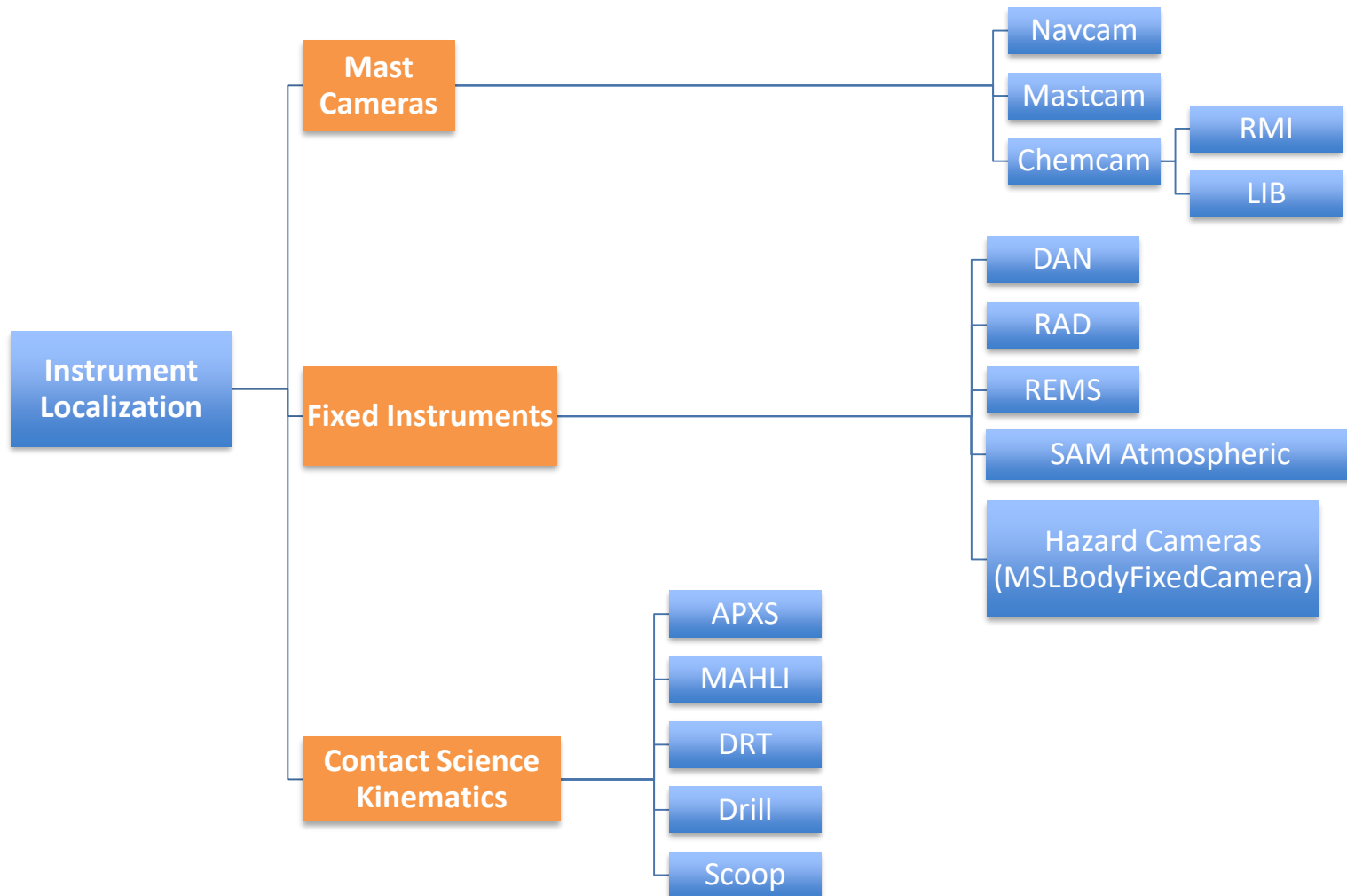


Science target Jake_Matejevic in MASTCAM 100, RMI, and MAHLI. <http://mars.jpl.nasa.gov/multimedia/images/?ImageID=4792>.
NASA/JPL-Caltech/MSSS



Localizing Science Targets: every laser shot, every integration, every image, everywhere for MSL.

Instrument Localization



METERS

- APXS_0526
- MASTCAM_0635
- MARDI_0635
- MAHLI_Stowed_0635
- DAN_Active_0635
- CHEMCAM_0636
- CCAM_BLIND_0582
- ▲ MCAM_BLIND_0606
- MSLICE_Targets_0637
- ★ Current Position
- End of Drive Position
- Actual Traverse

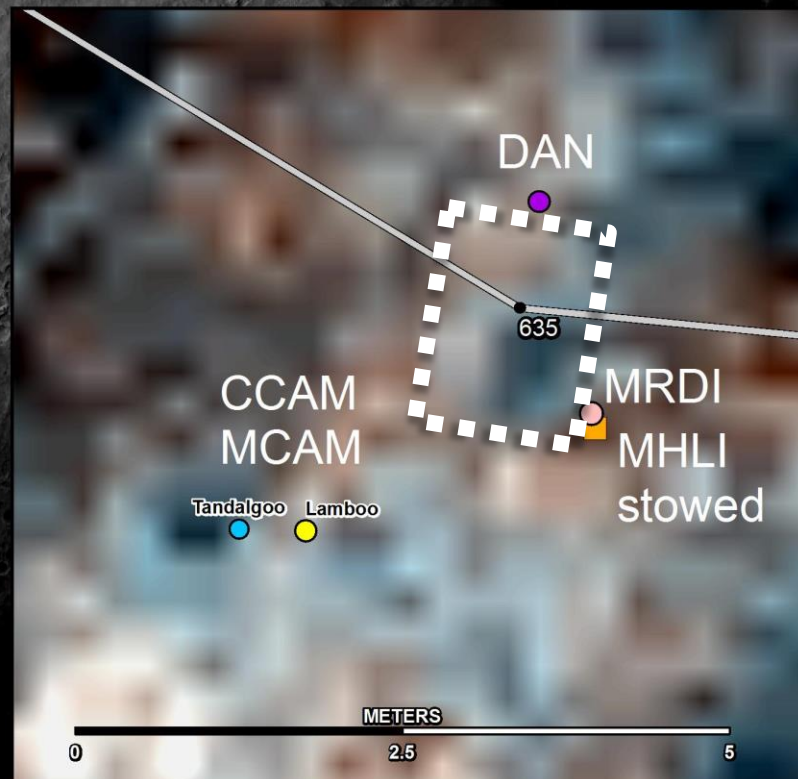
Oodles of Data

BRADBURY
LANDING

YELLOWKNIFE
BAY

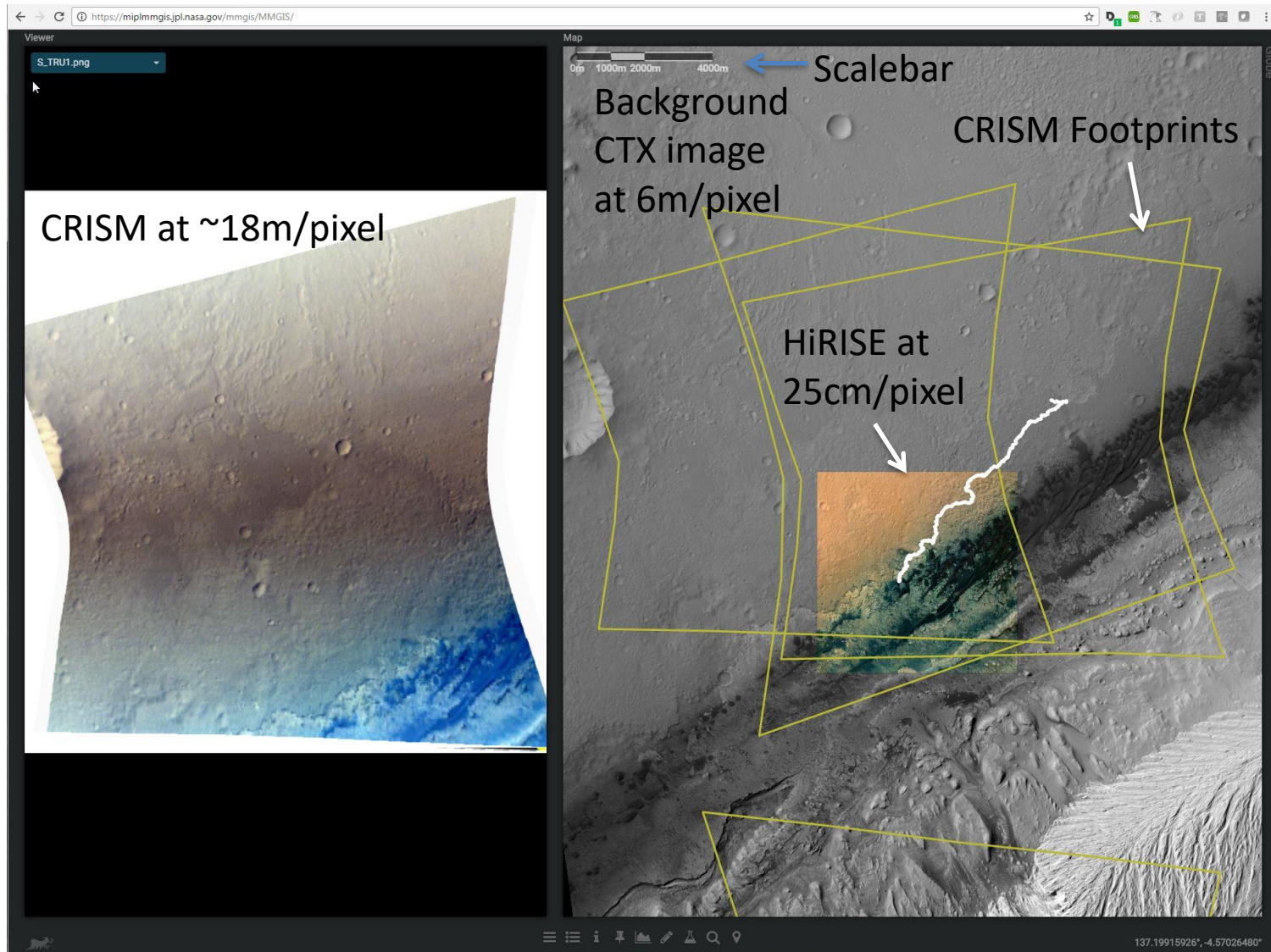
377

636



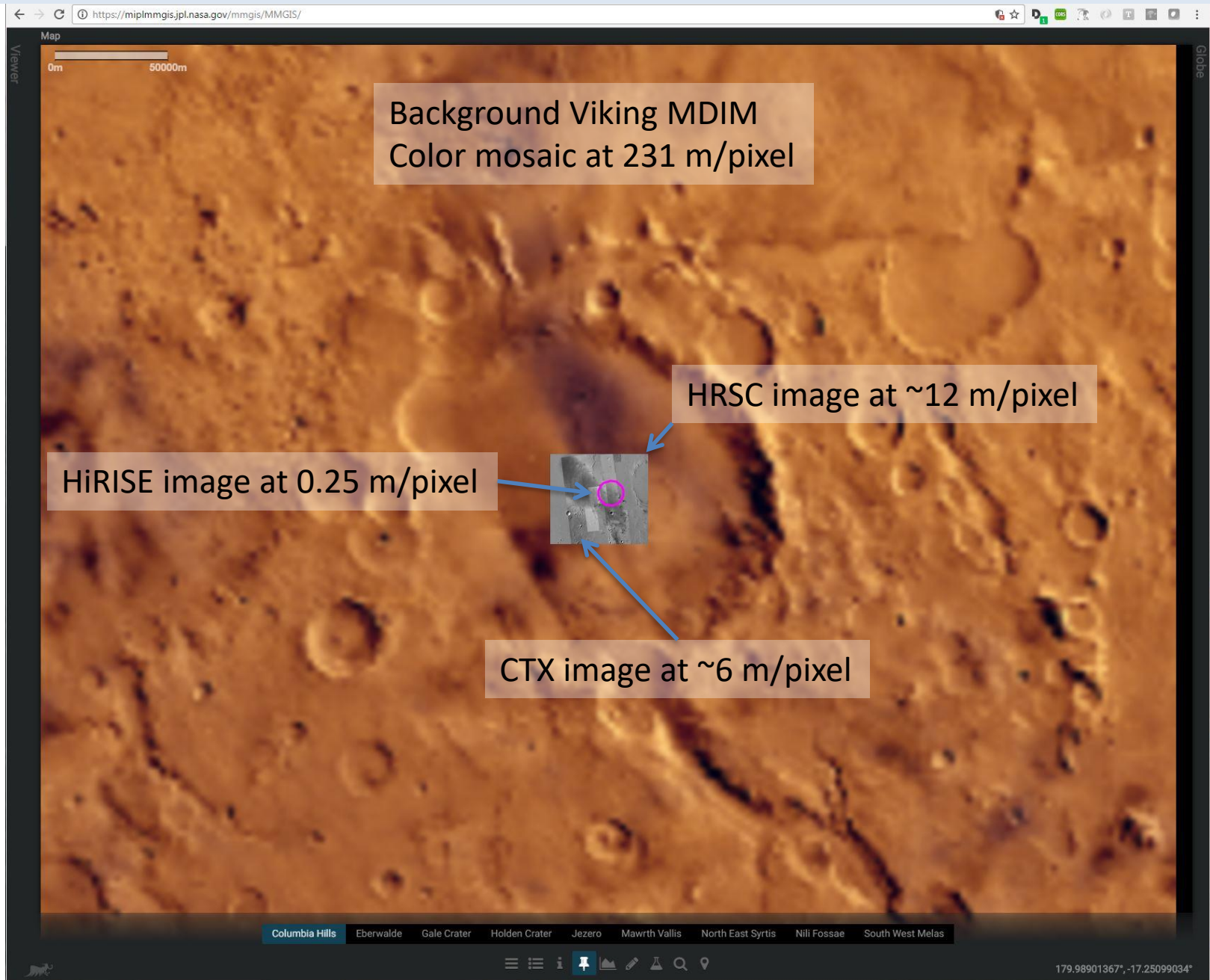
Original Image Preview

Co-registered image map view



Coordinates

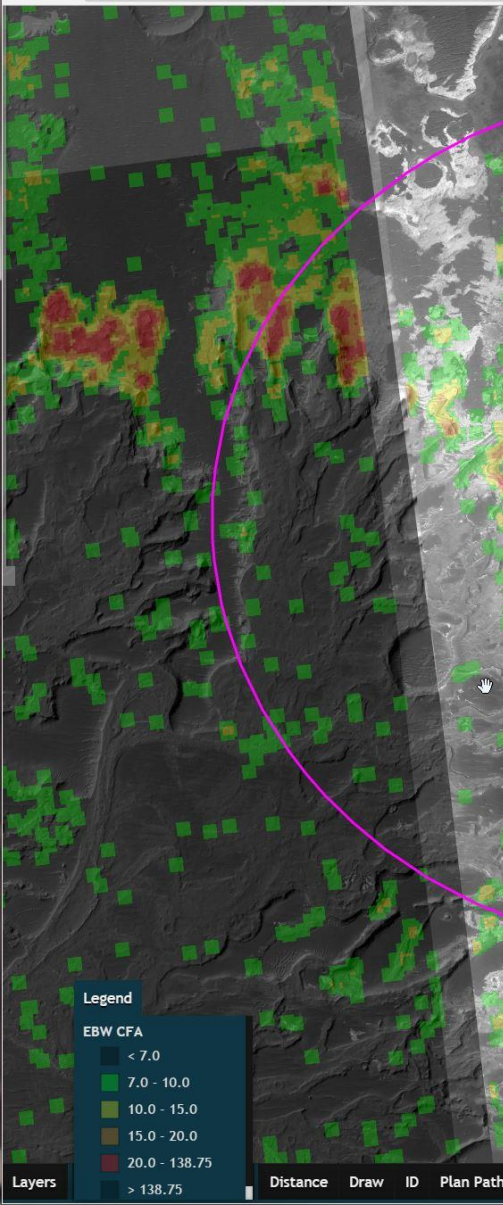
Interactive georeferenced maps at many different resolutions



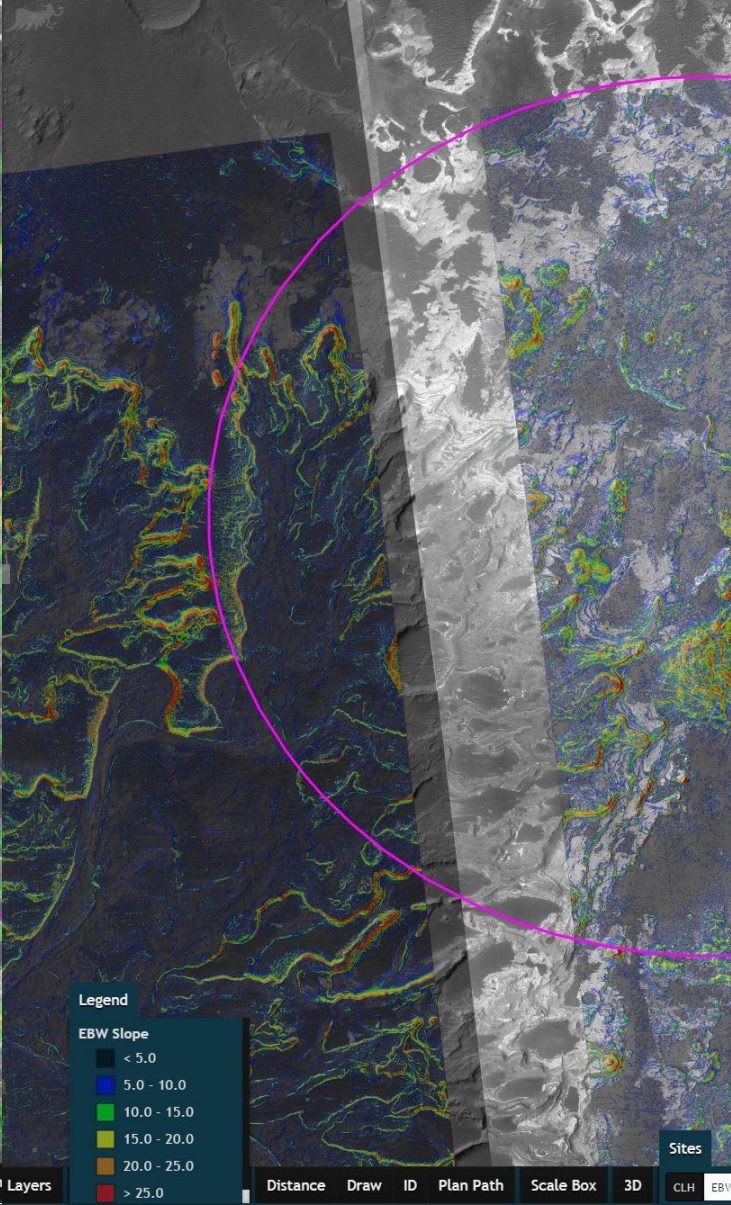
Ability to overlay multiple co-registered data sets

%Rocks/Area

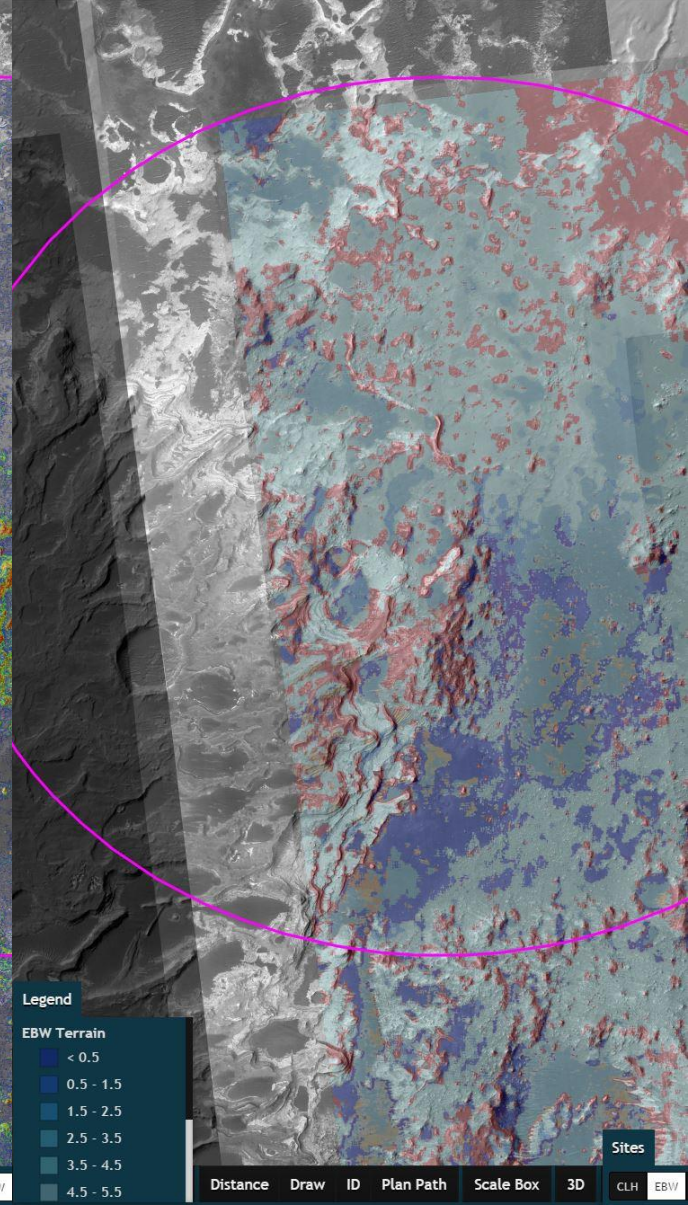
← → ↻ miplmmgis.jpl.nasa.gov/mmgis/MMWebGIS/Missions/MTT/MTT.html



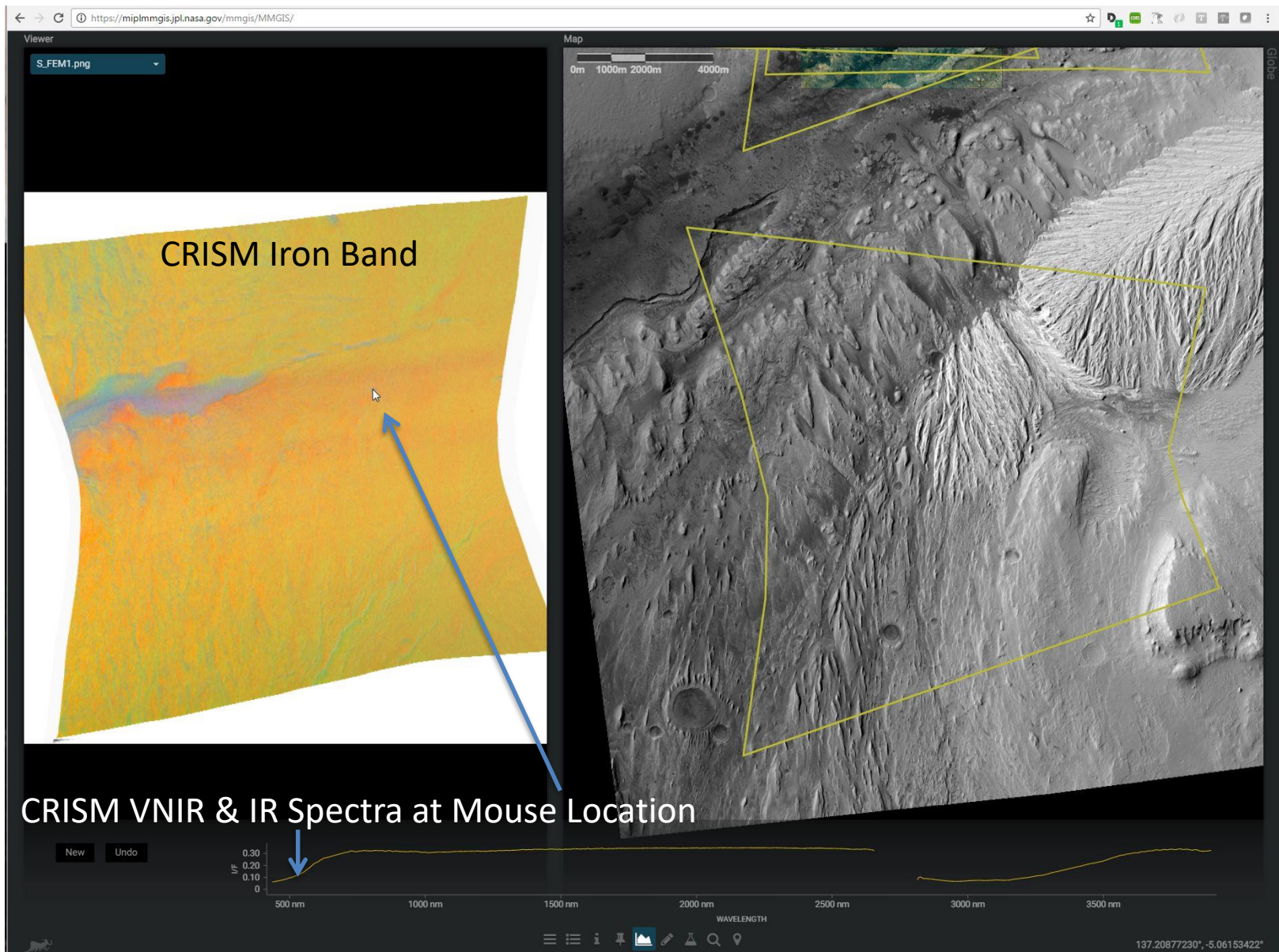
%Slope



Terrain Index



Sample raw data, including multiband floating-point images.

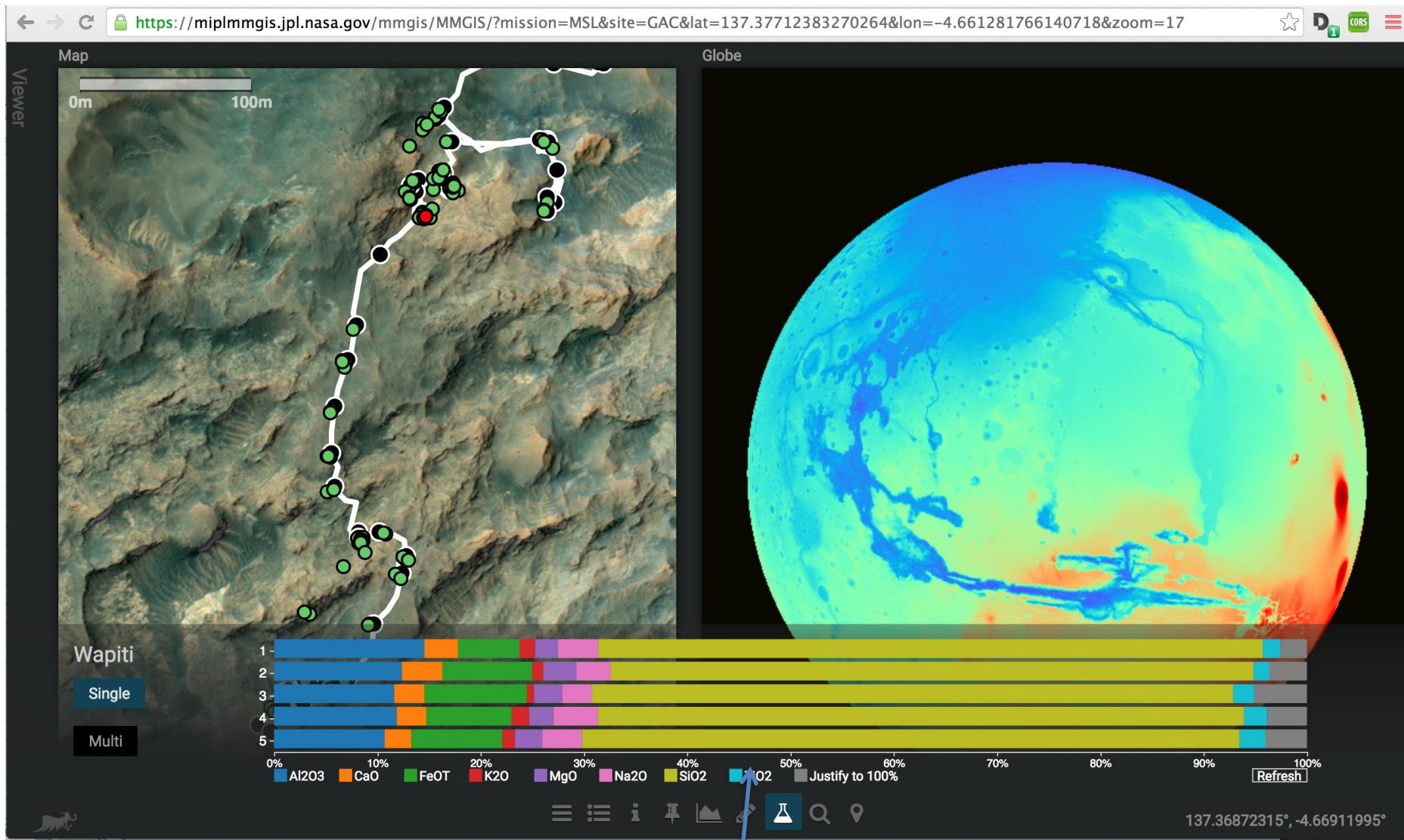


Provide tools to measure distance and create elevation profiles



Elevation cross-section from DEM
(can also be spectra)

“Quick looks” and 3D views



CHEMCAM Oxide values for target “Wapiti” on a 2D map and a 3D view of Mars elevation.

MMGIS Future Goals:

- **Release software as part of NASA AMMOS toolkit. (late 2017/2018).**
- **Support for all mission types: rover, lander, orbital.**
- **MMGIS as a prototype for Mars2020 rover campaign planning and InSight lander.**